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# Capital Concentration and Economic Growth: Interacting Income Inequality with Capital Accumulation

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## I. Introduction

A great deal of literature has been devoted to the study of economic growth in the field of macroeconomics, while income inequality remains a topic of frequent discussion in political science circles. However, the intersection of the two has received less attention, and the literature in this subfield of political economy is mixed. Recent trends in the composition of Western income distributions offer an opportunity to study the effect that a more hierarchical distribution of earnings may have on economic output. For instance, the concentration of resources may heavily influence the productivity of physical capital, which has implications on output. Previous literature has postulated a fundamental inequality within the market system: due to the dynamics of the capital-income ratio, the rate of return on capital must remain greater than the growth of national income (Piketty, 2014). In other words, the annual yield of aggregate private capital must be greater than the annual growth of aggregate labor income. As a consequence, resources concentrate, and this may be the leading driver of the recent trend in income divergences. This hypothesis stands in contrast to the most prominent prediction of the relationship between income inequality and economic development (Kuznets, 1955).

The purpose of this paper is to scrutinize both of the aforementioned hypotheses by attempting to identify a capital concentration term and to observe its relationship with patterns of economic output. Previous literature has neglected to adequately examine a potential interaction between income inequality and capital stock. This relationship should not be over-looked, as a more hierarchically pronounced distribution of incomes may differentially affect growth patterns conditional on a country's capital endowment. In other words, capital-intensive economies may not evidently experience any negative effects on growth associated with increasing income disparities. This may be due to massive supply chains of physical capital that drive national output. Labor intensive economies, on the other hand, may experience barriers to growth as a consequence of income concentration. This could be the effect of low capital stock inhibiting the ability to construct these supply chains to begin with, contrasting the traditionally accepted relationship between inequality and growth. Therefore, the interaction between capital stock and the composition of earnings distributions must be examined to revise existing hypotheses about these distributions and their effect on economic growth.

## II. Background

### *A. Income Inequality & Development*

Kuznets (1955) famously postulated that within-nation income inequality follows a bell curve throughout a nation's economic development. The theory was predicated on the observed conditions of pre-industrialized societies, in which the standard of living is low, due to the lack of efficiently distributed resources. In simpler terms, everyone in a pre-industrialized economy tends to be equally poor. Kuznets then argued that income inequality rises throughout development due to the division of labor, and the market's fundamental inclination to incentivize particular industries over others due to consumer demand. Eventually, disparities in earnings would peak, after which incomes would converge and return to a sustainably low level.[1] This is known as the "Kuznets Curve." If contemporary indicators are accurate, it seems Kuznets successfully predicted the relationship between income inequality and growth for the first half of development. The second half of his prediction has since been challenged by a number of economists, as observed trends in earnings disparities have seemingly contradicted the Kuznets Curve hypothesis.

Recent trends in global inequality have been most notably presented by Milanović (2016). Through historical analysis Milanović determines that "inequality in the United States increased between Independence…and the Civil War…and then continued to rise until the early twentieth century, when it is generally considered to have reached its peak."[2] During the post-Depression recovery era, "US inequality decreased steadily until the end of World War II." It then remained at a historical low of 35 Gini points until bottoming out in 1979. In the following decades, income inequality began to rise once again, surpassing 40 Gini points after 2010. It is for this reason, judging from multiple other similar case studies of Western nations, that Milanović proposes his theory of Kuznets Waves. His prediction is that post-industrialized nations will experience oscillations on the Gini index after development because there is no fundamental economic mechanism that drives income convergence. Rather, Milanović hypothesizes that variations in a country's Gini coefficient are the consequence of both "malign" and "benign" forces. The former refers to idiosyncratic events such as wars, civil conflict, and epidemics, while the latter consists of non-destructive influences. These include social pressures through politics, widespread education, demand for social protection, and technological changes that benefit low-skilled workers.

### *B. Tectonic Motivators of Inequality*

When studying within-country inequality throughout history, the timeline can be divided into three distinctive periods: 1) the pre-industrial age, or everything prior to the 1880s; 2) the post-industrial revolution period, which spans from the 1880s to the 1980s; and 3) the current era which began in the 1980s, and has continued to the present. During the preindustrial revolution period, inequality was largely difficult to measure because it was produced erratically by malign forces. As the West entered the post-industrialized era, within-nation inequality began to rise. This is consistent with the Kuznets hypothesis. At this point, changes in inequality became a manifestation of benign forces.

To be sure, these benign forces were implicit in Kuznets's prediction. In fact, Kuznets explicitly claimed that underdeveloped nations experience income inequality precisely because they have no mechanism to mitigate the compounding effect of earnings concentration. This is evident in the following quote:

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[1] The hypothesized reasons for this long-run convergence will be further explained below.

[2] The Gini index is the most widely used estimation for income inequality. Developed by Italian statistician Corrado Gini (1912), the Gini index captures the statistical distribution of incomes within a given country.

> "There is no empirical evidence to check this conjectural implication, but it is suggested by the absence, in these [underdeveloped] areas, of the dynamic forces associated with rapid growth that in the developed countries checked the upward trend of the upper-income shares that was due to the cumulative effect of continuous concentration of past savings; and it is also indicated by the failure of the political and social systems of underdeveloped countries to initiate the governmental or political practices that effectively bolster the weak positions of the lower-income classes."[3]

At this point, it is necessary to challenge the inevitability inherent in the claims asserted by Kuznets and Milanović. Perhaps the oscillations in income disparities are the product of Schumpeterian creative destruction. Perhaps it is the nature of a market economy to produce inequalities as a consequence of productivity advancements and increases in living standards. This may indeed be the case, but a second-level analysis suggests this perspective may be short-sighted. According to Schumpeter (1842), the creative destruction associated with dynamic markets is justified for the sake of aggregate growth. However, the very aim of increasing productivity holds within it a subtle, yet profoundly negative counter-effect.

### *C. The Piketty Critique*

Piketty (2014) presents two "fundamental laws of capitalism." The second law states that the smaller an economy's steady-state growth rate, the greater share its capital has in national income. This is pertinent commentary considering the observation that post-industrialized economies experience slower growth rates than those in the development process. This signifies further slowing of growth will lead to capital dominating labor in its share of national income. This is not necessarily detrimental from an initial examination. However, Piketty also presents what he refers to as "the fundamental inequality of capitalism," that $r > g$ where $r$ denotes the rate of return on capital and $g$ denotes the growth rate, measured by national income.[4] If this inequality holds, resources concentrate at the top of the wealth distribution because capital gains outpace wage growth and these gains provide access to more capital.[5]

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[3] Kuznets, Simon. "Economic growth and income inequality." *The American economic review* 45, no. 1 (1955): 24.

[4] The rate of return on capital varies depending on the type. For instance, real estate in the West returns approximately 3 percent a year while realized capital gains from financial markets return around 7 percent a year. Moreover, a firm's pool of wealth is also empirically indicative of the return it receives from investment. This is because, in general, more wealth means more liquid cash that can be spent on premier wealth fund managers. The economic principle of price signaling would state that wealth managers who charge more will find the investments that return the highest rate. This is also empirically shown in *Capital in the Twenty-First Century*. (Thomas Piketty and Arthur Goldhammer. *Capital in the Twenty-First Century*. Cambridge Massachusetts: The Belknap Press of Harvard University Press, 2014.)

[5] Income and wealth should not be conflated, nor should their respective distributions. However, they are inextricably connected. Wealth can be thought of as an individual's pool of assets – including mortgages, financial holdings, manufacturing equipment, etc. – while income is a steady stream leading into that pool. Income contributes to overall wealth and when it changes, so does its impact on an individual's pool of wealth. Further, the higher an individual's income is, the more accessible additional assets are, creating a

Piketty's work has since been critically examined and challenged (Acemoglu and Robinson, 2014; Blume and Durlauf, 2015; Ray, 2015; Irmen et al., 2016). The most pressing criticism of his work regards his failure to endogenize the discount rate. That being said, Irmen et el. find that Piketty's second rule remains robust in their analysis, which does endogenize the discount rate, although the dynamics that determine its existence are different from those Piketty hypothesizes. Rather, an increase in the discount rate yields a decline in growth, and a lower capital-income ratio while simultaneously increasing the rate of return on capital. Because the proportionate increase in steady-state *r* dominates the decline in the capital-income ratio, the price effect outweighs the volume effect.

Regardless, Piketty's second law remains largely robust and suggests implications for growth. If capital's share of national income increasingly dominates labor's as an economy's growth rate slows, income becomes primarily derived from capital. This income may be a return directly from that capital, or it may be labor income which reflects dexterity with that capital. A smaller pool of labor that is more productive in relation to advanced capital lowers the proclivity for any given individual to produce a technological change which will contribute to future productivity. The primary combatant to such undesirable outcomes is investment in human capital as well as research and development. Although Romer's (1990) model of endogenous technological change identifies the role of R&D in facilitating aggregate growth, no term is included to address the consequences of the distribution of these gains, which, according to Piketty, inevitably concentrate without the presence of Milanović's benign forces.

## III. Theory and Empirical Model

The classic Solow growth model (1956) states that a nation's output is dependent on two fundamental stocks which every nation possesses – capital (*K*) and labor (*L*) – as well as a term for the productivity of both these stocks (*A*).

(1) $$Y = AK^{\alpha}L^{1-\alpha}$$

In the Solow model, *A* is taken as exogenous, however, more recent literature suggests that national institutions can facilitate shocks to their population's productivity. The contributions of Mankiw et al. (1992) identified human capital accumulation as a component of the Solow residual (*A*). This theory can be modeled using the following Cobb-Douglas production function:

(2) $$Y_{i,t} = A_{i,t}K_{i,t}^{\alpha}H_{i,t}^{\beta}L_{i,t}^{\gamma}$$

for country *i* during period *t*, in which *H* denotes human capital, and $\alpha$, $\beta$, and $\gamma$ represent elasticity parameters.

compounding divergence of wealth as someone moves up the income distribution. It is also important to note that capital returns income. This means that the aforementioned assets actually return rents or capital gains that are included when accounting income, once those capital gains are realized. Although inequality in both distributions has been exacerbated throughout the past 40 years, wealth is far more concentrated than income is.

There are typically three theoretical possibilities for the behavior of total factor productivity (*A*) over time; an exponentially increasing rate, an exponentially diminishing rate, or a unit increasing rate of residual growth. For simplicity, the effect of the *A* term on the future growth of the parameter ($\dot{A}$) is assumed to be 1 to 1. The model used in this paper will assume a 1 to 1 relationship between endogenous investment in *A* and future growth of *A*, consistent with the endogenous technological change model presented by Romer (1990). Aligned with previous literature, total factor productivity will be defined as follows:

(3) $$A_{i,t} = A_0 e^{g_{i,t}}$$

where $A_0$ is the initial level of technology in a country that grows exogenously at rate $g$. The Romer model takes technological innovation as non-exclusionary, however the model does not incorporate income divergences. There is reason to believe income inequality is a crucial component of the Solow residual, as income divergences are associated with decreases in population health (Kawachi and Kennedy, 1999; Lynch et al., 2000; Pickett and Wilkinson, 2014), and population health is of course associated with productivity.[6] This paper hypothesizes that technological innovation is dependent in part on externalities associated with income inequality, so that:

(4) $$g_{i,t} = \eta + \theta I_{i,t}$$

where η signifies exogenous variables that impact total factor productivity and *I* stands for income inequality. To summarize, although capital may be accumulating – which neoclassical models state is indicative of growth – the gains from that accumulation are concentrated, which may be detrimental to growth. Performing a log transformation of equation (2) produces the following empirical model which can be estimated using ordinary least squares and fixed effects:

(5) $$y_{i,t} = \eta + \theta i_{i,t} + \alpha k_{i,t} + \beta h_{i,t} + \gamma l_{i,t} + \varepsilon_{i,t}$$

The above empirical model will measure the effect of the variables of interest on level of GDP. In other words, the dependent variable is GDP, while equation (6) below estimates the effect of each independent variable on the GDP growth rate.

(6) $$y_{i,t-1} - y_{i,0} = \eta - \psi y_{i,0} + \theta i_{i,t} + \alpha k_{i,t} + \beta h_{i,t} + \gamma l_{i,t} + \varepsilon_{i,t}$$

[6] It is worth noting that there may be significant outliers. For instance, macroeconomic data shows a booming privatized healthcare industry in the U.S. This is an industry experiencing some of the greatest job growth in America, and it is possible that these gains are a direct consequence of an abnormally high Gini coefficient, relative to other Western nations, which demands innovation. In fact, "household consumption of health care services has grown steadily in the past 40 years as prices increase" which follows the trajectory of the U.S.'s rising placement on the Gini index. However, it is worth noting that healthcare makes up a small proportion of output in the U.S. and no empirical analysis has been run on this data in this paper ("US Health Care and Future Job Growth." Federal Reserve Bank of St. Louis. Federal Reserve Bank of St. Louis, May 20, 2018. https://www.stlouisfed.org/on-the-economy/2018/may/health-care-future-job-growth).

The left-hand-side of equation (6) signifies the growth rate of output to examine the effect of inequality on economic growth, rather than the level output. Equation (6) will be the linear model used for analysis moving forward.

## IV. Data and Analysis

Consistent with previous literature, educational attainment data obtained from Barro and Lee on years of schooling were used in this paper as a proxy for human capital. Different proxies for educational attainment were tested, but to remain consistent with the literature (Barro and Lee, 1993; Wolff, 2000) the average number of years of schooling obtained by the population over the age of 25 was determined to be the optimal metric for human capital. All other macroeconomic data was downloaded from the World Bank's World Development Indicators database. Gross fixed capital formation is used as a proxy for capital stock and total population is used for labor stock.

The Gini index was also obtained from the WDI database and is measured in whole integers. The Gini index is calculated using a Lorenz curve, which "plots the cumulative percentages of total income received against the cumulative number of recipients, starting with the poorest individual or household. The Gini index measures the area between the Lorenz curve and a hypothetical line of absolute equality."[7] The index is a scale from 0 to 100, representing ultimate equality and ultimate concentration of income, respectively. The higher the Gini coefficient, the more hierarchical the distribution of income is within a given country. The exactitude of the Gini index as a metric for inequality is often subject to scrutiny. Critics of the Gini coefficient suggest its scope is too narrow (Deaton and Case, 2020), it is overly sensitive to changes in the middle of the income distribution (Gastwirth, 2017), and that earnings distributions are better interpreted when stratified by decile or even centile (Piketty, 2014). To be sure, no singular proxy should be taken as the end-all metric of interpretation for any phenomenon. However, the Gini coefficient is the most precise and widely used proxy for income inequality because it is strongly "Lorenz-consistent." This means it satisfies four axiomatic properties which allow for the comparison of the index over time and across countries.[8] For these reasons, the Gini index was determined to be the optimal metric of analysis for income inequality at this time.

Additionally, initial GDP is included in the empirical model to hold constant the variation in GDP at the initial time period. Initial GDP is measured in 2010 U.S. dollars while the dependent variable (annual GDP growth) is measured in percentage terms calculated by the world bank using 2010 U.S. dollars.[9] The data was then converted to 5-year panel averages for empirical analysis. The regressions referred to below were run as fixed effects models to hold constant

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[7] "GINI Index (World Bank Estimate)," Data (The World Bank, 2019), https://data.worldbank.org/indicator/SI.POV.GINI.

[8] These are the Pigou-Dalton transfer principle, scale invariance, symmetry, and population-replication invariance. (Francisco Ferreira, "In Defense of the Gini Coefficient," World Bank Blogs (The World Bank, February 19, 2020), https://blogs.worldbank.org/developmenttalk/defense-gini-coefficient.)

[9] If level of GDP in 2010 U.S. dollars is used as the dependent variable, rather than GDP growth, the initial GDP variable dominates the regression output. This is because of how economically significant initial GDP is at determining the level of GDP in subsequent time periods.

time invariant country characteristics which may impact growth outside of the variables captured within the model.

Table 1 depicts the output from the initial, fixed effects regression as well as that of a second regression using a limited sample of just the member countries of the Organization of Economic Cooperation and Development (OECD). These countries are typically referred to as “advanced economies” and serve as a sample for the developed world.

**Table 1. Fixed Effects Models**

| VARIABLES | Full Sample | OECD Only |
|---|---|---|
| Gini-lnK Interaction | -0.036* | -0.073*** |
| | (0.019) | (0.023) |
| lnK | 5.388*** | 9.886*** |
| | (1.312) | (1.554) |
| Gini Coefficient | 0.733* | 1.761*** |
| | (0.417) | (0.567) |
| lnL | -8.625*** | -9.650*** |
| | (2.453) | (2.121) |
| Years of Schooling | 0.040 | 0.105 |
| | (0.249) | (0.237) |
| Initial GDP per Cap. | -11.842*** | -14.604*** |
| | (1.737) | (3.049) |
| | (2.089) | (1.901) |
| Constant | 117.029*** | 57.931 |
| | (42.173) | (39.688) |
| Observations | 445 | 128 |
| R-squared | 0.423 | 0.683 |
| Number of Countries | 117 | 34 |
| Time Effects | Yes | Yes |

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

*A. Full Sample Fixed Effects Model*

The initial output generated included a negative association between the logged term for labor stock (population) and GDP growth (-8.625), statistically significant at the 99% level. For the purpose of interpretation, take the following hypothetical as an example: for a country with the average level population, roughly 15 million people, and the sample average annual GDP growth rate of 3.74%, a 1% increase in labor stock, or 150,000 people, will decrease that country’s annual economic growth rate to 3.65%. The coefficient for human capital, average years of schooling for domestic population over the age of 25, is positive, although very small and not significant (.040), however this does not necessarily indicate the proxy used for human capital in this regression is subject to misspecification.[10]

The capital stock of each country included in the full-sample regression was recorded and stratified to determine the level of gross fixed capital associated with different percentiles of the sample capital distribution at the country level. The Gini-K interaction term was then evaluated at the 10th, 25th, 50th, 75th, and 90th percentiles to determine the marginal effect of inequality on growth, conditional on a given country's level of capital (relative to the sample distribution). *Table 2* displays the marginal effect of the Gini coefficient on growth, given the level of capital at each of the aforementioned percentiles:

**TABLE 2. Marginal Effect of Gini on GDP Growth**

| PERCENTILE OF THE SAMPLE CAPITAL DISTRIBUTION | MARGINAL EFFECT OF GINI ON GDP GROWTH |
|---|---|
| 10% | -0.109** |
| 25% | -0.064 |
| 50% | 0.003 |
| 75% | 0.070 |
| 90% | 0.133** |

*** p<0.01, ** p<0.05, * p<0.1

An increase on the Gini index of 1 point is associated with a .109 decrease in the economic growth rate for countries with capital at the 10th percentile of the sample capital distribution. This effect is statistically significant at the 95% level. The marginal effect of the Gini coefficient remains negative, but to a lesser extent for countries at the 25th percentile (-0.064), then becomes slightly positive at the 50th (0.003). The marginal effect increases further at the 75th percentile (0.070), and finally becomes significant again at the 90th (0.133), where it appears to have the greatest positive impact on growth. Given a country with the average growth rate of 3.74% and capital stock at the 10th percentile of the sample distribution (approximately $1.1 billion), a 1-point increase on the Gini index decreases economic growth to 3.63%.

The same technique was used to interpret the coefficient on capital, conditional on a given country's Gini coefficient. *Table 3* depicts the marginal effect of capital on growth, given the Gini index at the same percentiles:

[10] Multiple variables were used to proxy human capital in this regression including different variations of educational attainment from the Barro and Lee data set as well as the World Bank's Human Capital Index (HCI). None of the variables tested indicated statistical significance.

**TABLE 3. Marginal Effect of Capital on GDP Growth**

| PERCENTILE OF THE SAMPLE GINI DISTRIBUTION | MARGINAL EFFECT OF CAPITAL ON GDP GROWTH |
|---|---|
| 10% | 3.831*** |
| 25% | 3.820*** |
| 50% | 3.801*** |
| 75% | 3.776*** |
| 90% | 3.754*** |

*** p<0.01, ** p<0.05, * p<0.1

The marginal effect of capital is strong and positive for all percentiles of the Gini distribution tested. Moreover, the effect does not vary significantly between percentiles, but does appear to diminish as one moves up percentiles in the Gini distribution.

*B. OECD Sample Fixed Effects Model*

The fixed effects model was then run again with a limited sample of just Organization of Economic Coordination and Development (OECD) member countries. The OECD member countries were chosen for this sample because they approximate a relatively diverse sample of advanced economies. To further scrutinize the Kuznets hypothesis, it is crucial to delve deeper into the relationship between income inequality and growth in the post-industrialized world alone.

Labor stock (population size) in the OECD sample is once again negative, although the magnitude of its effect (-9.650) is 1 percentage-point higher than it is for the full country sample (-8.625). Thus, if a country with the average level population size in the OECD sample, roughly 14.5 million people, as well as the average OECD economic growth rate of 2.61% experienced a 1% increase in population size (roughly 145,000 people), its growth would fall to 2.51%. The coefficient on years of schooling increased in the OECD sample to 0.105 but remains statistically insignificant.

*Table 4* depicts the marginal effect of the Gini coefficient on economic growth, conditional on capital stock in the OECD countries:

**TABLE 4. Marginal Effect of Gini on GDP Growth (OECD SAMPLE)**

| PERCENTILE OF THE OECD SAMPLE CAPITAL DISTRIBUTION | MARGINAL EFFECT OF GINI ON GDP GROWTH |
|---|---|
| 10% | -0.023 |
| 25% | 0.034 |
| 50% | 0.088 |
| 75% | 0.136** |
| 90% | 0.173** |

*** p<0.01, ** p<0.05, * p<0.1

The marginal effect of Gini is negative at the 10th percentile of the capital distribution in the advanced economies, although extremely small and not statistically significant. The effect then becomes positive at the 25th percentile and marginally increases at the 50th percentile. The effect becomes significant at the 75th and 90th percentiles where it exceeds 0.100 percentage-points. At the 90th percentile of the OECD capital distribution, the marginal effect of a country's Gini coefficient becomes 0.173 percentage points. For interpretation, take the following example of country within the top decile of the sample capital distribution of the most advanced economies in the world: for a country with the average OECD growth rate of 2.61% and the capital stock at the 90th percentile of the OECD distribution (roughly $600 billion in gross fixed capital), a 1 point increase in the Gini coefficient would increase growth to 2.78%. *Table 5* depicts the marginal effect of capital on growth, conditional on Gini, for the OECD sample.

The marginal effect of capital on economic growth for the OECD countries is similar to that of the full-country sample, although slightly higher at each percentile. This is likely the case because of other components of capital productivity outside the model that are positively associated with capital accumulation, although at a diminishing rate. For instance, trade openness may be a greater predictor of economic growth than capital stock is for smaller countries that are low in capital, while the opposite may be true for larger countries with an abundance of natural resources (Alesina and Wacziarg, 1998).

**TABLE 5. Marginal Effect of Capital on GDP Growth (OECD Sample)**

| PERCENTILE OF THE OECD SAMPLE GINI DISTRIBUTION | MARGINAL EFFECT OF CAPITAL ON GDP GROWTH |
|---|---|
| 10% | 3.838*** |
| 25% | 3.831*** |
| 50% | 3.819*** |
| 75% | 3.808*** |
| 90% | 3.788*** |

*** p<0.01, ** p<0.05, * p<0.1

*C. Quantile Regression*

As a consequence of growth variation, ordinary least squares (OLS) regression analysis has the potential to yield results with less accuracy than other models because its significance is dependent on the mean squared error. Further specification of the findings presented above required an examination of the median, and so a quantile regression model was run in addition to the OLS model. The quantile regression model runs an independent regression for each of the percentiles specified above with respect to the absolute value of the errors. The quantiles are percentiles of the dependent variable distribution, in this case, economic growth. So, rather than interpreting the Gini-K interaction term by applying the full-sample coefficient to different levels of capital accumulation, the quantile model runs a regression for particular quantiles of economic growth. Because there is a different regression run for each quantile of the growth distribution, there is a different coefficient for each right-hand-side variable within each percentile. *Table 6* displays the output generated from the default quantile regression which uses the 50th percentile for analysis. The default quantile regression was run with robust standard errors using the variance-covariance matrix command. This command does not allow for the output to be stratified by quantile, which is why *Table 6* only features output at the median GDP growth level. The output for each independent quantile is displayed in *Table 7*. For now, attention should be drawn to *Table 6*.[11]

Note that labor stock (population) remains negative, and significant at the 99% level. One of the most intriguing facets of this initial quantile regression, however, is the coefficient on human capital. Keep in mind, the proxy used was the average number of years of schooling for the population aged 25 and older. The coefficient states this proxy for human capital is positively associated with economic growth (0.177). For interpretive purposes, this means that a 1-year increase in average years of schooling yields a 0.177 percentage-point increase in economic growth. Take for example a country experiencing the sample median growth rate of 3.76% and providing its citizens the sample educational attainment median of 7.20 years of schooling. If this country increases the number of years of schooling it provides its citizens to 8.20 years on average, the quantile regression model predicts that country's growth to increase to 3.94%.

**TABLE 6. Quantile Regression Summary Using the Median**

| VARIABLES | Quantile Regression |
|---|---|
| Gini-lnK Interaction | 0.009* |
| | (0.005) |
| lnK | 2.648*** |
| | (0.314) |
| Gini Coefficient | -0.194* |
| | (0.111) |
| lnL | -3.020*** |
| | (0.274) |
| Years of Schooling | 0.177*** |
| | (0.044) |
| Initial GDP per Cap. | -4.026*** |
| | (0.272) |
| Constant | 24.345*** |
| | (4.705) |
| Observations | 445 |
| Time Effects | Yes |
| Robust Standard Errors | Yes |

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

[11] Before moving on, it is crucial to note that unlike capital, high levels of growth are associated with the industrialization and development process. High accumulation of capital suggests a country is already developed, and so the 90th percentile of the capital distribution is a good proxy for the most developed and wealthiest nations. The 90th percentile of the growth distribution on the other hand, is associated with countries going through the industrialization process.

*Table 7* displays the regression output for each quantile of the sample growth distribution. First, note that the coefficient on labor stock, as well as its sign, remains robust and relatively consistent across quantiles. The most interesting facet of this output is once again the coefficients on educational attainment. For the bottom quantiles tested, the coefficient on years of schooling is actually negative, although insignificant. It quickly becomes positive at the 25$^{th}$ percentile of the sample growth distribution, although it remains insignificant. However, once the 50$^{th}$ percentile is reached, educational attainment becomes significant at the 99% level (0.177). The coefficient increases slightly at the 75$^{th}$ percentile (0.194) and remains significant at the 90% level. The quantile of particular interest here though is the 90$^{th}$, where the coefficient on years of schooling becomes 0.311. The model thus predicts that for a country at the 90$^{th}$ percentile of the sample growth distribution, the growth being 6.84%, and median capital stock ($13.2 billion worth of fixed capital), a 1-year increase in average educational attainment for the population aged 25 and older increases growth to 7.02%. Therefore, it seems that the human capital hypothesis in neoclassical growth theory is robust for countries above the 50$^{th}$ percentile of the sample growth distribution, or countries that are undergoing or phasing out of industrialization and thus require human capital development to facilitate productivity growth in addition to fixed assets. The lowest levels of growth (Q1 GDP: 0.94%; Q2 GDP: 2.24%) likely do not hold the fixed capital needed in order for educational attainment to make that capital significantly more productive.

**TABLE 7. Quantile Regression (Stratified)**

| VARIABLES | Q1 (.10) | Q2 (.25) | Q3 (.50) | Q4 (.75) | Q5 (.90) |
|---|---|---|---|---|---|
| Gini-lnK Interaction | 0.002 | 0.001 | 0.009 | 0.006 | 0.017 |
| | (0.011) | (0.006) | (0.006) | (0.007) | (0.011) |
| lnK | 3.540*** | 3.406*** | 2.648*** | 3.050*** | 1.972** |
| | (0.964) | (0.572) | (0.319) | (0.455) | (0.789) |
| Gini Coefficient | 0.006 | -0.018 | -0.194 | -0.116 | -0.365 |
| | (0.253) | (0.156) | (0.144) | (0.179) | (0.247) |
| ln L | -3.475*** | -3.333*** | -3.020*** | -3.455*** | -2.918*** |
| | (0.986) | (0.635) | (0.294) | (0.503) | (0.654) |
| Years of Schooling | -0.008 | 0.065 | 0.177*** | 0.194* | 0.311*** |
| | (0.152) | (0.094) | (0.064) | (0.099) | (0.082) |
| Initial GDP per Cap. | -4.277*** | -4.289*** | -4.026*** | -4.415*** | -4.156*** |
| | (1.094) | (0.646) | (0.348) | (0.476) | (0.682) |
| Constant | 12.534 | 14.698* | 24.345*** | 26.241*** | 39.736*** |
| | (11.657) | (7.686) | (6.182) | (8.071) | (9.965) |
| Observations | 445 | 445 | 445 | 445 | 445 |
| Time Effects | Yes | Yes | Yes | Yes | Yes |
| Robust SEs | No | No | No | No | No |

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Below is *Table 8*, which shows the marginal effect of the Gini coefficient on growth, conditional on the level of capital at each quantile. Note that the level of capital is logged. Additionally, the "effect of Gini" as well as the "effect of Gini-K interaction term" columns list the coefficients of either variable at each quantile.

**TABLE 8. Marginal Effect of Gini on GDP Growth by Quantile**

| QUANTILE OF SAMPLE GDP GROWTH DISTRIBUTION | GDP GROWTH AT QUANTILE | PERCENTILE OF THE SAMPLE CAPITAL DISTRIBUTION | MARGINAL EFFECT OF GINI ON GDP GROWTH |
|---|---|---|---|
| Q1 (10%) | 0.94% | 10% | 0.046 |
| | | 25% | 0.048 |
| | | 50% | 0.051 |
| | | 75% | 0.054 |
| | | 90% | 0.056 |
| Q2 (25%) | 2.24% | 10% | 0.011 |
| | | 25% | 0.013 |
| | | 50% | 0.015 |
| | | 75% | 0.017 |
| | | 90% | 0.019 |
| Q3 (50%) | 3.76% | 10% | -0.009 |
| | | 25% | 0.000 |
| | | 50% | 0.013 |
| | | 75% | 0.026 |
| | | 90% | 0.039 |
| Q4 (75%) | 5.32% | 10% | 0.015 |
| | | 25% | 0.021 |
| | | 50% | 0.031 |
| | | 75% | 0.040 |
| | | 90% | 0.049 |
| Q5 (90%) | 6.84% | 10% | -0.002 |
| | | 25% | 0.016 |
| | | 50% | 0.042 |
| | | 75% | 0.068 |
| | | 90% | 0.093 |

*** p<0.01, ** p<0.05, * p<0.1

The greatest marginal effect of Gini on growth is at the 90th percentile of the capital distribution within the 90th percentile of the growth distribution (0.093). Recall that the highest growth rates are associated with economic development and industrialization. Thus, Q5 is representative of countries undergoing development. Income inequality has the largest marginal effect on growth for countries at the 90th percentile of both the growth and capital distributions. For countries in the 90th percentile of growth and 10th percentile of capital, an increase in income inequality actually has a negative effect on growth. Note also that the fifth quantile exhibits the greatest range of the marginal effect of Gini. However, the individual figures in the table above do not matter as much as the trends they display.

The marginal effect of the Gini coefficient on growth appears to increase with capital stock at each quantile of the growth distribution, although there is no overall trend throughout the quantiles. In other words, independent of a country's economic growth rate, an increase in the Gini coefficient has a larger marginal effect on growth the more capital that country has. If nothing else, this indicates the significance of examining the interaction between income inequality and capital stock. It appears that an increase in capital stock yields a larger marginal effect of income inequality on growth. As capital accumulation seems to be positively correlated with the marginal effect of income concentration on growth, capital concentration must be examined alongside capital accumulation.

*Table 9* depicts the effect of capital on growth, conditional on the Gini coefficient at each quantile. Keep in mind, the Gini index is a scale from 0-100 of whole integers. A country cannot technically have a Gini coefficient that is not a whole number. The decimals were included for specification purposes, but it is not possible for a country to have a Gini coefficient of say, 29.1. Similar to the marginal effect of Gini, the marginal effect of capital increases conditional on the level of Gini increasing for all quantiles except for Q1. This means that for all but countries with the lowest growth, the marginal effect of capital on growth increases as income inequality increases. In other words, the higher the income inequality within a country, the greater the effect of capital on economic growth for quantiles 2-5.

When examining Q1, note that it contains both the highest and lowest marginal effects of capital. The highest is 3.595 at the lowest percentile of the sample Gini distribution. So, for countries at the $10^{th}$ percentile of the growth distribution (0.94%) and the $10^{th}$ percentile of the Gini distribution (29.1), the marginal effect of capital on growth is the greatest out of any quantile. This may be attributed to the fact that capital may be needed alongside consumer demand to spark the division of labor which produces the divergence of incomes. Perhaps growth and Gini are both so low because of a lack of capital, and so an increase in capital would spark both economic growth and income divergences. As aforementioned, the lowest marginal effect of capital on growth is also found in the first quantile (2.076). This may be the result of corruption in underdeveloped nations. Again, the most important takeaway from *Table 9* is the increasing trend in the marginal effect of capital within each quantile, excluding the first.

**TABLE 9. Marginal Effect of Capital on GDP Growth by Quantile**

| QUANTILE OF SAMPLE GDP GROWTH DISTRIBUTION | GDP GROWTH AT QUANTILE | PERCENTILE OF THE SAMPLE GINI DISTRIBUTION | MARGINAL EFFECT OF CAPITAL ON GDP GROWTH |
|---|---|---|---|
| Q1 (10%) | 0.94% | 10% (29.1) | 3.595 |
| | | 25% (32.6) | 3.468 |
| | | 50% (39.2) | 2.722 |
| | | 75% (47.5) | 3.141 |
| | | 90% (54.6) | 2.076 |
| Q2 (25%) | 2.24% | 10% (29.1) | 3.447 |
| | | 25% (32.6) | 3.452 |
| | | 50% (39.2) | 3.462 |
| | | 75% (47.5) | 3.474 |
| | | 90% (54.6) | 3.484 |
| Q3 (50%) | 3.76% | 10% (29.1) | 2.907 |
| | | 25% (32.6) | 2.938 |
| | | 50% (39.2) | 2.997 |
| | | 75% (47.5) | 3.070 |
| | | 90% (54.6) | 3.134 |
| Q4 (75%) | 5.32% | 10% (29.1) | 3.234 |
| | | 25% (32.6) | 3.256 |
| | | 50% (39.2) | 3.298 |
| | | 75% (47.5) | 3.350 |
| | | 90% (54.6) | 3.395 |
| Q5 (90%) | 6.84% | 10% (29.1) | 2.480 |
| | | 25% (32.6) | 2.542 |
| | | 50% (39.2) | 2.657 |
| | | 75% (47.5) | 2.802 |
| | | 90% (54.6) | 2.926 |

*** p<0.01, ** p<0.05, * p<0.1

The quantile regression output above has been included to display trends rather than individual figures. Significance testing yielded statistically insignificant differentiation between quantiles, so the numbers featured in tables 8 and 9 should be observed cautiously. As a consequence, the following discussion section will focus primarily on the OLS regressions reported above.

*D. Testing a Non-linear Gini Effect*

Recall the Kuznets hypothesis; that income inequality will follow the path of a bell curve if mapped against development. If this is indeed the case, a non-linear relationship between income inequality and growth would be expected. In theory, a parabolic relationship would suit the

Kuznets hypothesis optimally. Table 10 displays two models which test the fit of a non-linear relationship between the Gini coefficient and economic growth. The first model excludes the Gini-capital interaction term to remain consistent with Kuznets's prediction. The second includes the main effects and interaction effects of income inequality and capital stock, assuming a continuous, non-linear relationship.

**TABLE 10. Continuous Relationship Model**

| VARIABLES | Continuous Model (No Interaction) | Continuous Model |
|---|---|---|
| lnK | 3.781*** | 4.232* |
| | (0.844) | (2.248) |
| Gini Coefficient | -0.030 | -0.470 |
| | (0.230) | (2.087) |
| Gini-lnK Interaction | | 0.021 |
| | | (0.092) |
| $Gini^2$ | -0.000 | 0.014 |
| | (0.003) | (0.024) |
| $Gini^2$-lnK Interaction | | -0.001 |
| | | (0.001) |
| lnL | -8.853*** | -8.603*** |
| | (2.616) | (2.502) |
| Years of Schooling | 0.138 | 0.033 |
| | (0.257) | (0.247) |
| Initial GDP per Cap. | -11.720*** | -11.823*** |
| | (1.746) | (1.757) |
| Constant | 154.714*** | 140.988** |
| | (46.930) | (59.704) |
| Observations | 445 | 445 |
| R-squared | 0.410 | 0.424 |
| Number of Countries | 117 | 117 |

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

In both models, no variation of the Gini coefficient is significant in predicting GDP growth, nor are the interaction terms. This suggests a bell curve may not be the most precise way of theorizing the relationship between inequality and growth. Given the possibility pf Kuznets Waves, hypothesized by Milanović, future research may be keen to consider other non-linear specifications.

## V. Discussion

Contradictory to the Kuznets hypothesis, the above analysis identifies a negative association between income inequality and growth for countries with the lowest levels of capital stock. Moreover, the output does not become significant again until the 90$^{th}$ percentile of the sample capital distribution where it is positive. When the OECD member countries are observed alone, it is only at the 75$^{th}$ and 90$^{th}$ percentiles of the capital distribution where income inequality is significant and positive. The quantile regression, on the other hand, shows a positive association between Gini and growth for all quantiles tested. However, the 10$^{th}$ and 90$^{th}$ percentiles of the capital distribution yield the largest coefficients. However, considering the fixed effects models yielded the only statistically significant results from the Gini-K interaction term, it can be tentatively concluded that income inequality is negatively associated with GDP growth for countries at the bottom decile of the sample capital distribution, while it is positively associated with GDP growth for countries in the top decile of the sample capital distribution. Moreover, the OECD-only sample seems to show that the richest countries with the most capital experience the greatest positive effects on GDP growth resulting from income inequality.

There appears to be no market dynamic which converges incomes while generating growth. In fact, it seems the richest countries with the most capital benefit in terms of economic growth as their position on the Gini index rises. This may prove problematic regarding market incentives. There is of course a point on the Gini index where social orientation breaks down if inequality is too high. Future research could benefit from the operationalization of negative social externalities that are produced as a corollary income inequality, considering markets themselves appear to continuously incentivize the divergence of incomes. The findings above suggest Milanović's hypothesis of Kuznets Waves is more robust. It seems as though income inequality, when plotted against growth, follows a positive linear path with an intercept below zero. Milanović's malign and benign forces, which exist outside of the marketplace, are likely the primary drivers of income convergence.

To offer insight into why the Kuznets hypothesis may not be accurate over the long term, take the following hypotheses: Firstly, it is possible that growth in underdeveloped nations requires a large pool of accessible resources to spark the division of labor and future growth. Concentrated resources may create a structural hurdle for a developing economy, as the general population would not have the resources to enter competitive markets which demand innovation. In contrast, rich countries with advanced economies may require the concentration of resources to produce innovation that yields a unit productivity increase relative to previous innovation. In other words, more resources may be needed to produce an equal shock to productivity. If this is the case, income concentration may lead to larger supply chains which may be increasingly needed to hurdle previous technological advancements. Moreover, countries in the upper decile of the sample capital distribution are likely to be home to capital intensive industries while the global south specializes in producing labor-intensive goods. If this is the case, perhaps income inequality has differential effects on economies contingent on the ratio of capital to labor.

There may also be misspecifications within the model presented in this paper. For instance, there may be a multicollinearity problem between capital accumulation and income inequality, as each likely perpetuates the other. This is one of Piketty's hypotheses, mentioned earlier. Additionally, omitted variables such as trade openness and public safety nets both likely impact innovation and productivity and may or may not be associated with income inequality. Future analysis may benefit from the inclusion of these variables as well as different proxies for capital concentration. This paper focused on an interaction term between income inequality and capital stock. In the future, it may prove beneficial to study the capital-income ratio as a proxy of capital concentration, or the physical to human capital ratio. A two-stage least squares model may be warranted as well, considering there may be a simultaneity problem between income inequality and GDP growth. Further, more finely disaggregated data on industry concentration may serve as a catalyst in pushing future research forward. Capital concentration by industry may be the next step in teeming out the relationship between capital concentration and growth.

## VI. Conclusion

The relationship between income inequality and growth is increasingly complex. Capital, labor, and the many determinants of productivity generate an interplay at the macro level which cannot easily be distilled. This paper's findings suggest the Kuznets hypothesis may be obsolete in predicting economic growth patterns. It is clear that the dynamics which govern the market system are slightly different this century than they were in the last, and a reexamination of the factors that drive inequality may be necessary. This analysis shows that income inequality, when interacted with capital stock, does not seem to follow the path of a bell curve. Instead, there seems to be a linear relationship between the two, the intercept of which is negative. Income inequality is actually negatively associated with economic growth for countries in the bottom decile of the sample capital distribution and increases with capital stock level. There appear to be many factors at play which provide stipulations and contradictions to the Kuznets hypothesis, suggesting a greater focus on the relationship between income inequality, capital stock, and economic growth is warranted.

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